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(54) Hybrid optical wavelength division multiplexer-demultiplexer.

(57) There are disclosed a hybrid optical wavelength division multiplexer for one-directional transmission, a hybrid optical wavelength division demultiplexer for one-directional transmission, and a hybrid optical wavelength division multiplexer-demultiplexer for bidirectional transmission. The multiplexer-demultiplexer has light-emitting diodes and photodetectors integral with an optical wavelength division multiplexer-demultiplexer, with input and output ports comprising electric interfaces, with the result that there is required no optical fiber coupling system between the light-emitting diodes and photodetectors and the optical wavelength division multiplexer-demultiplexer. The hybrid multiplexer, demultiplexer, or the multiplexer-demultiplexer is small in size and light in weight. The hybrid optical wavelength division multiplexer for one-directional transmission has collimator lenses for converting light of different wavelengths emitted from the light-emitting diodes into parallel beams of light, interference filters of different transmittivities for multiplexing the parallel beams of light, and another collimator lens for converging and coupling the modulated beams of light to the common-port optical fiber. The hybrid optical wavelength division demultiplexer for one-directional transmission demultiplexes light of different wavelengths from the common-port optical fiber, the demodulated light being detected by the photodetectors. The hybrid optical wavelength division multiplexer-

demultiplexer for bidirectional transmission is a combination of the multiplexer and demultiplexer.

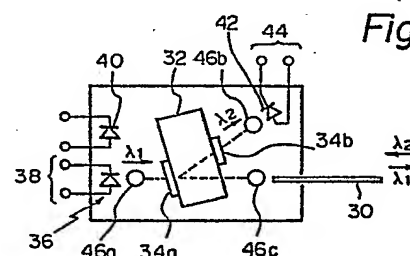


Fig. 2

HYBRID OPTICAL WAVELENGTH DIVISION
MULTIPLEXER-DEMULTIPLEXER

BACKGROUND OF THE INVENTION

1. Field of the invention:

The present invention relates to a hybrid optical wavelength division multiplexer-demultiplexer in which a light-emitting diode and a photodiode are integrally constructed with an optical wavelength division multiplexer-demultiplexer.

2. Description of the Prior Art:

Optical wavelength division multiplexing transmission systems give plural independent optical signal channels with different wavelengths over a single optical fiber. Such transmission system includes optical wavelength division multiplexer and demultiplexer coupled respectively to the ends of an optical fiber transmission path for separating and combining the optical signals. A prior optical wavelength division multiplexer-demultiplexer for bidirectional transmission, for example, is connected by optical fibers to ends of transmission, receiving, and common ports. The other ends of the transmission and receiving ports are respectively coupled by optical fibers to a light-emitting module (such as a laser diode (LD) module or an LED module) and a photodetector module (such as a PIN PD module or an APD module) for conversion between electric and optical signals.

FIG. 1 of the accompanying drawings illustrates an arrangement of a conventional optical wavelength division multiplexer-demultiplexer for bidirectional transmission in which

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a light-emitting module and a photodetector module are coupled to an optical wavelength division multiplexer-demultiplexer. A light-emitting module 6 is composed of a light-emitting diode 2 and a lens 4, and coupled to an optical wavelength division multiplexer-demultiplexer 10 through a transmission-port optical fiber 8. A photodetector module 16 is composed of a photodiode 12 and a lens 14, and coupled to the optical wavelength division multiplexer-demultiplexer 10 through a receiving-port optical fiber 18. The illustrated prior optical wavelength division multiplexer-demultiplexer for bidirectional transmission is employed to transmit two optical signals of wavelengths λ_1 and λ_2 . An optical signal having the wavelength λ_1 is generated from the light-emitting diode 2 in response to an electric signal applied to electric terminals 1, and is transmitted to a common-port optical fiber 26 through the lens 4, the transmission-port optical fiber 8, lenses 20, 22 and another optical system. An optical signal having the wavelength λ_2 is received from the common-port optical fiber 26, and is transmitted through the lens 22, a lens 24, the receiving-port optical fiber 18 to the photodetector module 16 by which the optical signal is converted into an electric signal outputted through electric terminals 28. The conventional system is necessarily of the above arrangement since the coupling efficiency would be lowered if the distances between the light-emitting diode and the optical fiber and between the photodiode and the optical fiber were increased. More specifically, where the lenses 20, 24 and the lens 22 are coupled by optical fibers, the optical system is symmetrical and hence the coupling efficiency would not be subjected to an undue reduction if the distances between the lenses 20, 22 and the lenses 24, 22 were increased. However,

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1 the coupling distances between the light-emitting diode and the
2 optical fiber and between the photodiode and the optical fiber
3 cannot be increased appreciably. It has been required to reduce
4 the distance from the light-emitting diode 2 and the lens 4 up
5 to the entrance of the transmission port optical fiber 8 and
6 the distance from the photodiode 12 and the lens 14 up to the
7 entrance of the receiving-port optical fiber 18, and to provide
8 the optical fibers 8, 18 to couple the modules 6, 16 to the
9 optical wavelength division multiplexer-demultiplexer 10.

10 Therefore, it has been necessary to provide the expensive
11 light-emitting and photodetector modules 6, 16 other than the
12 optical wavelength division multiplexer-demultiplexer 10. The
13 overall construction has been complex and the entire size has
14 been large, resulting in a loss in the optical coupling system.
15 Another problem has been that there is difficulty in handling
16 the input and output systems as the transmission and receiving
17 ports are coupled to the optical fibers.

18 19 SUMMARY OF THE INVENTION

20 It is an object of the present invention to provide a
21 hybrid optical wavelength division multiplexer-demultiplexer in
22 which transmission and receiving ports are composed of electric
23 interfaces to dispense with any optical fiber coupling system
24 between a light-emitting diode and an optical wavelength division
25 multiplexer-demultiplexer and between a photodiode and an optical
26 wavelength division multiplexer-demultiplexer.

27 Another object of the present invention is to provide a
28 hybrid optical wavelength division multiplexer-demultiplexer
29 for bidirectional transmission, or a hybrid optical wavelength
30 division multiplexer for one-directional transmission, or a

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1 hybrid optical wavelength division demultiplexer for one-
2 directional transmission, which is composed of a reduced number
3 of optical coupling components, easy to handle, small in size,
4 and light in weight.

5 According to the present invention, a hybrid optical
6 wavelength division multiplexer for one-directional transmission
7 includes a pair of collimator lenses for converting light into
8 parallel beams of light and for converging parallel beams of
9 light, between a plurality of light-emitting means for producing
10 light of different wavelengths and a single common-port optical
11 fiber. Light beams of different wavelengths emitted from the
12 light-emitting means in response to applied electric signals are
13 converted by the collimator lenses into parallel rays of light
14 which are passed through or reflected by an optical system
15 composed of interference filters of different characteristics,
16 so that the rays of light are multiplexed and applied to the
17 common-port optical fiber via another collimator lens. The
18 interference filters have different transmissivity character-
19 istics to pass certain optical wavelengths while reflecting
20 light of other wavelengths. The interference filters are
21 applied to side surfaces of a glass block interposed between
22 the collimator lenses for applying the light emitted from the
23 light-emitting means to the common-port optical fiber. The
24 light produced from the light-emitting means is first converted
25 by the collimator lenses into parallel beams of light, which
26 are passed through or reflected by the interference filters.
27 The light beams are thereafter converged by the other collimator
28 lens and coupled to the common-port optical fiber.

29 A hybrid optical wavelength division demultiplexer,
30 according to the present invention includes a collimator lens

1 for converting light of different wavelengths transmitted from a
2 single common-port optical fiber into parallel beams of light,
3 which are passed through or reflected by interference filters
4 with different transmissivities applied to a glass block, whereby
5 the light beams are demultiplexed. The demultiplexed optical
6 signals are then converged by respective collimator lenses and
7 detected by respective photodetectors which produce corresponding
8 electric signals.

9 A hybrid optical wavelength division multiplexer-
10 demultiplexer for bidirectional transmission is a combination
11 of the above hybrid optical wavelength division multiplexer for
12 one-direction transmission and the above hybrid optical
13 wavelength division demultiplexer for one-direction transmission.
14 One or more optical signals of different wavelengths emitted
15 from the light-emitting means in response to applied electric
16 signals are multiplexed and coupled to the single common-port
17 optical fiber, and one or more optical signals of different
18 wavelengths received from the common-port optical fiber are
19 demultiplexed and detected by corresponding photodetectors
20 which convert the optical signals into electric signals.

21 The above and other objects, features and advantages of
22 the present invention will become more apparent from the follow-
23 ing description when taken in conjunction with the accompanying
24 drawings in which preferred embodiments of the present invention
25 are shown by way of illustrative example.

26 27 BRIEF DESCRIPTION OF THE DRAWINGS

28 FIG. 1 is a schematic view of a conventional optical
29 wavelength division multiplexer-demultiplexer;

30 FIG. 2 is a schematic view of a hybrid optical wavelength

1 division multiplexer-demultiplexer for bidirectional transmission
2 according to the present invention;

3 FIG. 3(a) and 3(b) are diagrams showing the characteristics
4 of interference filters employed in the optical wavelength
5 division multiplexer-demultiplexer shown in FIG. 2;

6 FIG. 4(a) is a schematic view of a hybrid optical wavelength
7 division multiplexer for one-directional transmission of two
8 waves according to the present invention;

9 FIG. 4(b) is a schematic view of a hybrid optical wavelength
10 division demultiplexer for one-directional transmission of two
11 waves according to the present invention;

12 FIG. 5 is a schematic view of a hybrid optical wavelength
13 division multiplexer-demultiplexer for bidirectional transmission
14 of four waves according to the present invention;

15 FIGS. 6(a) through 6(d) are diagrams showing the character-
16 istics of interference filters employed in the optical wavelength
17 division multiplexer-demultiplexer shown in FIG. 5;

18 FIG. 7(a) is a schematic view of a hybrid optical wavelength
19 division multiplexer for bidirectional transmission of four
20 waves according to the present invention;

21 FIG. 7(b) is a schematic view of a hybrid optical wavelength
22 division demultiplexer for bidirectional transmission of four
23 waves according to the present invention;


24 FIG. 8 is a diagram illustrative of coupling efficiency vs.
25 distance characteristics obtained when a laser diode (LD) is
26 employed; and

27 FIG. 9 is a diagram illustrative of coupling efficiency vs.
28 distance characteristics obtained when a light-emitting diode
29 (LED) is employed.
30

DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the present invention, a pair of spherical lenses is provided as collimator lenses respectively between a light-emitting diode and an optical fiber and between a photodiode and the optical fiber, the arrangement being such that light emitted from the light-emitting diode is converted by one of the spherical lens into parallel rays of light which are then converged by the other spherical lens into the optical fiber. With the foregoing construction, the coupling efficiency would not be lowered if the distance between the two lenses were increased. It is therefore possible to provide various optical systems between the two lenses for separating and combining optical signals of plural different wavelengths without lowering the coupling efficiency.

FIG. 2 show a hybrid optical wavelength division multiplexer-demultiplexer according to the present invention. The hybrid optical wavelength division multiplexer-demultiplexer includes a common-port optical fiber 30, a glass block 32, interference filters 34a, 34b applied to the glass block 32 and having different wavelength passbands characteristics, a light-emitting diode (LD or LED) 36 for generating light having a wavelength λ_1 , electric signal transmitting terminals 38 connected to the light-emitting diode 36, an automatic power control photodiode 40 for detecting a portion of light emitted from the light-emitting diode 36 to keep the amount of light from the light-emitting diode 36 at a constant level, a photodiode 42 for detecting light of a wavelength λ_2 transmitted over the common-port optical fiber 30, electric signal receiving terminals 44 coupled to the photodiode 42, and spherical lenses 46a, 46b, 46c.



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Each of the interference filters 34a, 34b comprises several tens of layers formed by vapor deposition on the glass block 32 for developing an optical interference to pass light of a certain wavelength only while reflecting light of other wavelengths. FIG. 3(a) shows a characteristic curve of the interference filter 34a, the transmissivity being greatest at the wavelength λ_1 with light reflected in other wavelengths. FIG. 3(b) shows a characteristic curve of the interference filter 34b, the transmissivity being greatest at the wavelength λ_1 with light reflected in other wavelengths.

Operation of the arrangement of FIG. 2 is as follows: An electric signal applied to the terminals 38 is converted by the light-emitting diode 36 into light of the wavelength λ_1 which is converted by the spherical lens 36a into parallel rays of light. The rays of light then pass through the interference filter 34a and are converged by the spherical lens 46c into light which falls on and is transmitted by the common-port optical fiber 30. Light of the wavelength λ_2 received from the common-port optical fiber 30 is converted by the spherical lens 46c into parallel beams of light which pass through the glass block 32 and are reflected by the interference filter 34a. The reflected light then passes through the interference filter 34b and is focused on the photodiode 42 via the spherical lens 46b. The photodiode 42 converts the applied light into an electric signal which is issued to the electric signal receiving terminals 44. External connection ports of the hybrid optical wavelength division multiplexer-demultiplexer for bidirectional transmission comprise the electric signal transmitting terminals 38 for driving the light-emitting diode 36, the electric signal receiving terminals 44 coupled to the photodiode 42, and the

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1 common-port optical fiber 30. These three ports are mounted
2 integrally on the single device, in which the optical system
3 is also integrally disposed. Since the hybrid optical
4 wavelength division multiplexer-demultiplexer of the invention
5 is electrically coupled to external sources through the terminals
6 38, 44, the input and output systems can easily be handled, and
7 any loss caused by the optical coupling system can be reduced.

8 FIGS. 4(a) and 4(b) are illustrative respectively of a
9 hybrid optical wavelength division multiplexer for one-
10 directional transmission of two waves and a hybrid optical
11 wavelength division demultiplexer for one-directional trans-
12 mission of two waves. The hybrid optical wavelength division
13 multiplexer for one-directional transmission of two waves as
14 shown in FIG. 4(a) includes two light-emitting diodes 36a, 36b
15 for emitting light beams of different wavelengths which are
16 multiplexed and transmitted over a single common-port optical
17 fiber 30. More specifically, electric signals applied to
18 electric signal transmitting terminals 38a, 38b are converted
19 by the light-emitting diodes into two optical signals having
20 wavelengths λ_1 , λ_2 , respectively. The light of the wavelength
21 λ_1 from the light-emitting diode 36a is converted by a
22 spherical lens 46a into parallel beams of light which pass
23 through an interference filter 34a and a glass block 32. The
24 light is then converged by a spherical lens 46c and transmitted
25 over the common-port optical fiber 30. Light of the wavelength
26 λ_2 from the light-emitting diode 36b is converted by a
27 spherical lens 46b into parallel beams of light which pass
28 through an interference filter 34b and the glass block 32 to
29 the interference filter 34a. Since the interference filter 34a
30 passes the light of the wavelength λ_1 and reflects light of

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1 other wavelengths, as shown in FIG. 3(a), the light of the
2 wavelength λ_2 is reflected by the interference filter 34a. The
3 light is then converged by the spherical lens 46c and trans-
4 mitted over the common-port optical fiber 30. Therefore, the
5 optical signals of the wavelengths λ_1, λ_2 are multiplexed over
6 the common-port optical fiber 30. Although the arrangement of
7 FIG. 4(a) has an automatic power control photodiode such as
8 shown in FIG. 2, it is omitted from illustration as it has
9 the same operation and function. Such an automatic power
10 control photodiode is also omitted from illustration in each
11 of embodiments described below.

12 The hybrid optical wavelength division demultiplexer for
13 one-directional transmission of two waves as shown in FIG. 4(b)
14 serves to demultiplex optical signals of two different
15 wavelengths transmitted over a common-port optical fiber. Light
16 of a wavelength λ_1 passes through an interference filter 34a
17 and detected by a photodetector 42a which issues an electric
18 signal to electric signal receiving terminals 44a. Light of
19 a wavelength λ_2 is reflected by the interference filter 34a,
20 passes through an interference filter 34b, and then detected
21 by a photodiode 42b which issues an electric signal to electric
22 signal receiving terminals 44b. With the arrangements of FIGS.
23 4(a) and 4(b), each of the hybrid optical wavelength division
24 multiplexer and demultiplexer has optical functional components
25 such as spherical lenses, interference filters, and a glass
26 block, all disposed between the light-emitting diode and photo-
27 diode and the common-port optical fiber.

28 FIG. 5 shows a hybrid optical wavelength division
29 multiplexer-demultiplexer for bidirectional transmission of four
30 waves. The multiplexer-demultiplexer of FIG. 5 can multiplex

two optical signals having wavelengths λ_1 , λ_3 and send them to a common-port optical fiber, and also can demultiplex two optical signals having wavelengths λ_2 , λ_4 transmitted from the common-port optical fiber. The multiplexer-demultiplexer includes interference filters 34a, 34b, 34c, 34d having characteristics as shown in FIGS. 6(a) through 6(d), respectively, for passing light of certain wavelengths and reflecting light of other wavelengths. More specifically, as shown in FIG. 6(a), the interference filter 34a has a maximum permissivity at a wavelength λ_1 and reflects light in other wavelengths. As shown in FIGS. 6(b), 6(c) and 6(d), the interference filters 34b, 34c and 34d have maximum permissivities at wavelengths λ_2 , λ_3 and λ_4 , respectively, and reflect light in other wavelengths. In FIG. 5, light of the wavelength λ_1 emitted from a light-emitting diode 36c is converted by a spherical lens 46d into parallel beams of light which pass through the interference filter 34a and a glass block 32. The light is then converged by a spherical lens 46f and coupled to a common-port optical fiber 30. Light having the wavelength λ_3 emitted from a light-emitting diode 36d is converted by a spherical lens 46e into parallel beams of light which pass through the interference filter 34c and the glass block 32. The light is then reflected by the interference filters 34d, 34a, and converged by the spherical lens 46f and coupled to the common-port optical fiber 30. Light of the wavelength λ_2 received from the common-port optical fiber 30 is converted by the spherical lens 46f into parallel beams of light which are reflected by the interference filter 34a. The light is then passed through the interference filter 34b, and converged by a spherical lens 46g and detected by a photodetector 42c, which



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1 issues an electric signal to electric signal receiving terminals
2 44c. Light of the wavelength λ_4 received from the common-port
3 optical fiber 30 is reflected successively by the interference
4 filters 34a, 34b, 34c, after which the light is passed through
5 the interference filter 34d and detected by the photodetector
6 42d, from which an electric signal is produced via electric
7 signal receiving terminals 44d.

8 FIGS. 7(a) and 7(b) respectively show a hybrid optical
9 wavelength division multiplexer for bidirectional transmission
10 of four waves and a hybrid optical wavelength division
11 demultiplexer for bidirectional transmission of four waves. The
12 hybrid optical wavelength division multiplexer for bidirectional
13 transmission of four waves as shown in FIG. 7(a) is a modifi-
14 cation of the arrangement of FIG. 4(a) so as to be able to
15 transmit four waves, and employs four interference filters, as
16 shown in FIG. 6, for multiplexing four optical signals of
17 different wavelengths. In FIG. 7(a), optical signals having
18 wavelengths $\lambda_1, \lambda_3, \lambda_2, \lambda_4$, emitted from light-emitting diodes
19 36c, 36d, 36e, 36f in response to electric signals applied
20 respectively to electric signal receiving terminals 38c, 38d,
21 38e, 38f are multiplexed and coupled to a common-port optical
22 fiber 30. The hybrid optical wavelength division demultiplexer
23 for bidirectional transmission of four waves as shown in FIG.
24 7(b) is modification of the arrangement of FIG. 4(b) so as to
25 be able to receive four waves, and employs four interference
26 filters, as shown in FIG. 5, for demultiplexing four optical
27 signals of different wavelengths transmitted from the common-
28 port optical fiber 30. In FIG. 7(b), optical signals having
29 wavelengths $\lambda_1, \lambda_2, \lambda_3, \lambda_4$, transmitted from the common-port
30 optical fiber 30 are detected by photodiodes 42e, 42c, 42f, 42d

1 which issue electric signals through electric signal receiving
2 terminals 44e, 44c, 44f, 44d, respectively.

3 With the hybrid optical wavelength division multiplexer-
4 demultiplexers shown in FIGS. 2, 4, 5 and 7, it is necessary to
5 provide an increased distance between the light-emitting diodes
6 and the common-port optical fibers. In the illustrated
7 embodiments, light emitted from the light-emitting diode is
8 converted by the spherical lens into parallel beams of light
9 which are directed toward the spherical lens in front of the
10 common-port optical fiber. FIG. 8 shows coupling efficiency vs.
11 distance characteristics obtained by employing a laser diode
12 in the foregoing embodiments. The graph of FIG. 8 has a
13 horizontal axis indicating the distance between the spherical
14 lens adjacent to the light-emitting diode and the spherical lens
15 adjacent to the common-port optical fiber, and a vertical axis
16 representing a coupling efficiency η (= power transmitted to the
17 common-port optical fiber/total power emitted from the light-
18 emitting diode). The common-port optical fiber used is a
19 standard optical fiber having a fiber core of a diameter of
20 50 μm , an outside diameter of 125 μm (50/125 GI), and an N.A.
21 (numerical aperture) of 0.20. The characteristic curve in FIG.
22 8 clearly shows that the coupling efficiency of the hybrid
23 optical wavelength division multiplexer-demultiplexer of the
24 embodiments of the invention will not be reduced if the coupling
25 distance is in the range up to 50 mm. While the present
26 invention has been described as being applied to multiplexing
27 and demultiplexing of four wavelengths in the hybrid optical
28 wavelength division multiplexer, the hybrid optical wavelength
29 division demultiplexer, and the hybrid optical wavelength
30 division multiplexer-demultiplexer, the invention is theoretic-

1 cally applicable to multiplexing and demultiplexing of as many
2 wavelengths as desired. However, if too many wavelengths
3 were involved, the distance between the light-emitting diodes
4 and the common-port optical fiber would be increased, thus
5 causing reduction of the coupling efficiency. It was experimen-
6 tally confirmed that up to six waveformed can be multiplexed
7 and demultiplexed without lowering the coupling efficiency
8 according to the present invention.

9 FIG. 9 shows coupling efficiency vs. distance character-
10 istics obtained by employing light emitted from an LED. The data
11 of FIG. 9 was measured using the same optical fiber as described
12 in the above experiment, and the graph of FIG. 9 has horizontal
13 and vertical axis indicative of the same quantities as those
14 in FIG. 8. Fig. 9 indicates, as with FIG. 8, that the coupling
15 efficiency will not be lowered if the coupling distance is
16 increased.

17 Although certain preferred embodiments have been shown
18 and described, it should be understood that many changes and
19 modifications may be made therein without departing from the
20 scope of the appended claims.
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What is claimed is:

1. A hybrid optical wavelength division multiplexer-demultiplexer for bidirectional transmission of light of different wavelengths by multiplexing optical signals of different wavelengths produced in response to electric signals applied to one or more electric signal receiving terminals and coupling the multiplexed optical signals to a common-port optical fiber, and by demultiplexing optical signals of different wavelengths transmitted from the common-port optical fiber and outputting electric signals corresponding to the demultiplexed optical signals to one or more electric signal transmitting terminals, said hybrid optical wavelength division multiplexer-demultiplexer comprising:

(a) one or more light-emitting means adapted to be connected to said one or more electric signal receiving terminals respectively for generating the optical signals of different wavelengths in response to the electric signals applied to said one or more electric signal receiving terminals;

(b) one or more photodetectors adapted to be connected to said one or more electric signal transmitting terminals respectively for converting the optical signals of different wavelengths transmitted from the common-port optical fiber into the electric signals;

(c) a first group of lenses for converting the optical signals from said one or more light-emitting means into parallel beams of light;

(d) a second lens for converging and coupling the parallel beams of light to the common-port optical fiber and for converting the optical signal of different wavelengths from the common-port optical fiber into parallel beams of light;

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1 (e) a third group of lenses for converging and applying the
2 second parallel beams of light from the common-port to said
3 photodetectors; and

4 (f) a glass block and a plurality of interference filters
5 applied to sides of said glass block for passing light of certain
6 wavelengths only while reflecting light of other wavelengths
7 to demultiplex the optical signals of different wavelengths
8 received from the common-port optical fiber and couple the
9 demultiplexed optical signals through said third group of lenses
10 to said corresponding photodetectors respectively, and to
11 multiplex the optical signals of different wavelengths emitted
12 from said one or more light-emitting means and couple the
13 multiplexed optical signal through said second lens to the
14 common-port optical fiber.

15 2. A hybrid optical wavelength division multiplexer for
16 one-directional transmission of light of different wavelengths
17 by multiplexing optical signals of different wavelengths
18 produced in response to electric signals applied to electric
19 signal receiving terminals and coupling the multiplexed optical
20 signals to a common-port optical fiber, said hybrid optical
21 wavelength division multiplexer comprising:

22 (a) a plurality of light-emitting means adapted to be
23 connected to the electric signal receiving terminals respectively
24 for generating the optical signals of different wavelengths in
25 response to the electric signals applied to the electric signal
26 receiving terminals;

27 (b) a first group of lenses for converting the optical
28 signals from said light-emitting means into parallel beams of
29 light;

30 (c) a second lens for converging and coupling the parallel

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1 beams of light to the common-port optical fiber; and

2 (d) a glass block and a plurality of interference filters
3 applied to sides of said glass block for passing light of certain
4 wavelengths only while reflecting light of other wavelengths to
5 multiplex the optical signals of different wavelengths emitted
6 from said light-emitting means and couple the multiplexed optical
7 signals through said second lens to the common-port optical fiber.

8 3. A hybrid optical wavelength division demultiplexer for
9 one-directional transmission of light of different wavelengths
10 by demultiplexing optical signals of different wavelengths
11 transmitted from a common-port optical fiber and issuing electric
12 signals corresponding to the demultiplexed optical signals to
13 electric signal transmitting terminals, said hybrid optical
14 wavelength division demultiplexer comprising:

15 (a) a plurality of photodetectors adapted to be connected
16 to the electric signal transmitting terminals respectively for
17 converting the optical signals of different wavelengths trans-
18 mitted from the common-port optical fiber into the electric
19 signals;

20 (b) a second lens for converting the optical signals of
21 different wavelengths from the common-port optical fiber into
22 parallel beams of light;

23 (c) a third group of lenses for converging and applying the
24 parallel beams of light from the common-port to said photo-
25 detectors; and

26 (d) a glass block and a plurality of interference filters
27 applied to sides of said glass block for passing light of certain
28 wavelengths only while reflecting light of other wavelengths to
29 demultiplex the optical signals of different wavelengths received
30 from the common-port optical fiber and couple the demultiplexed

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1 optical signals through said third group of lenses to said
2 corresponding photodetectors respectively.

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Fig. 1 PRIOR ART

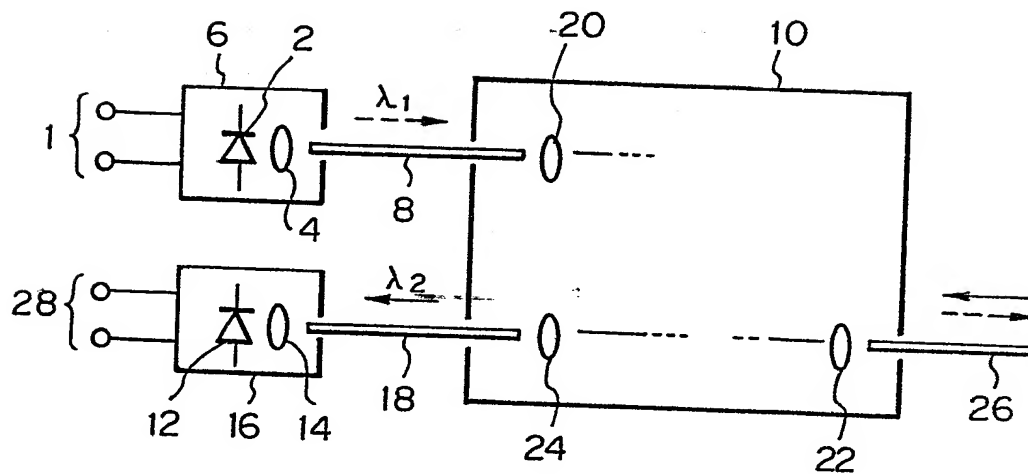


Fig. 2

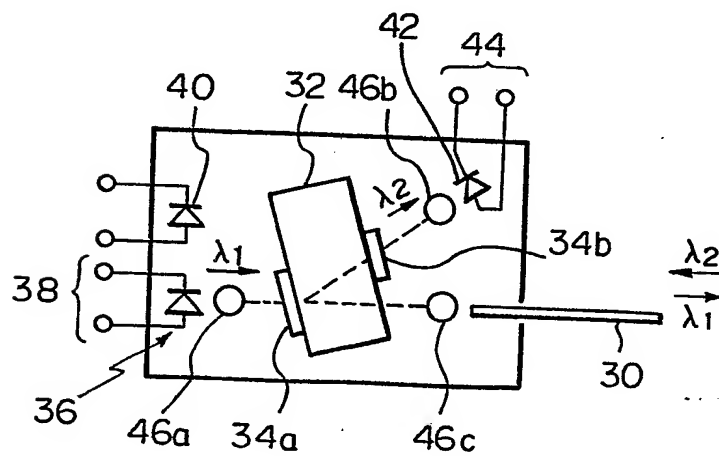


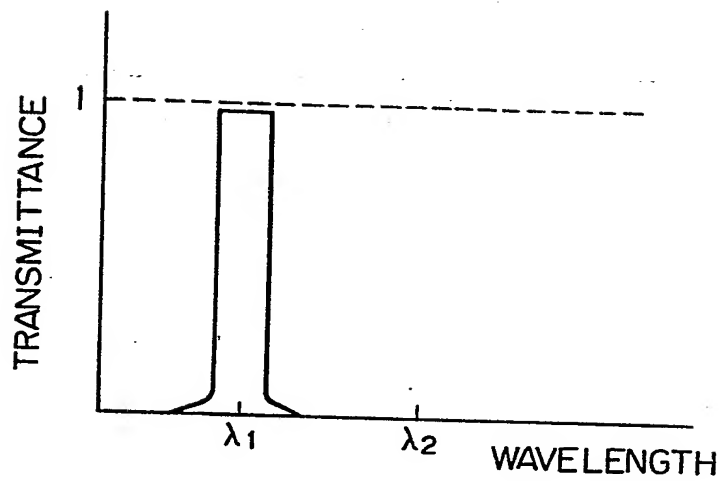
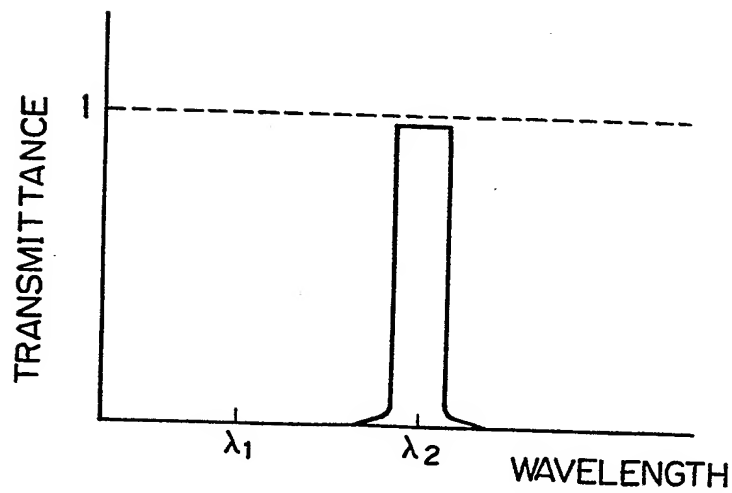
Fig. 3(a)*Fig. 3(b)*

Fig. 4(a)

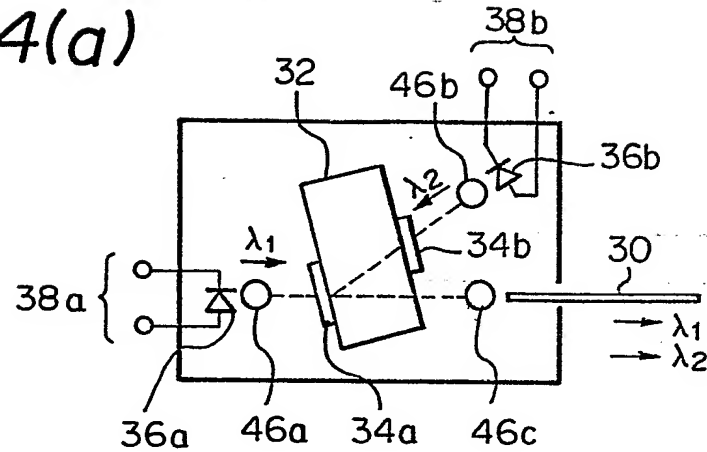


Fig. 4(b)

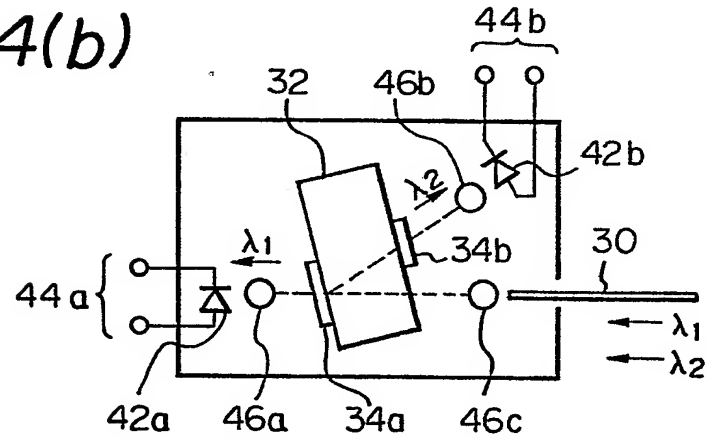


Fig. 5

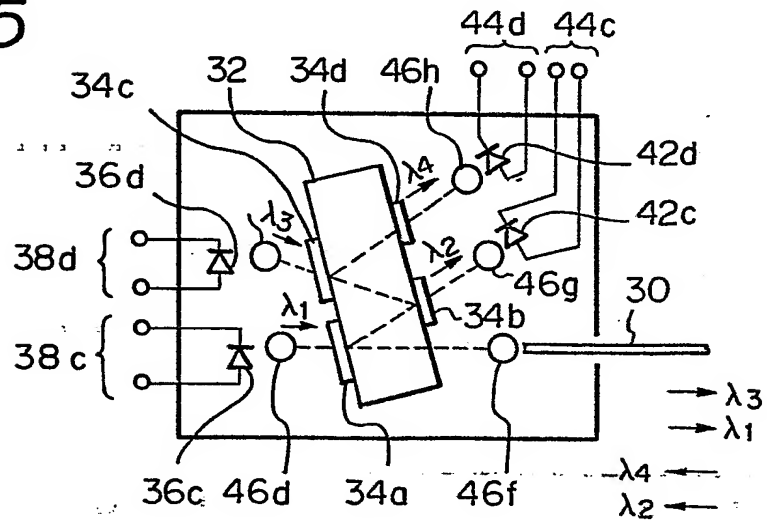


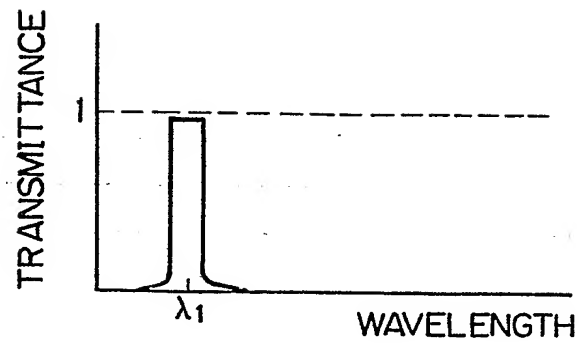
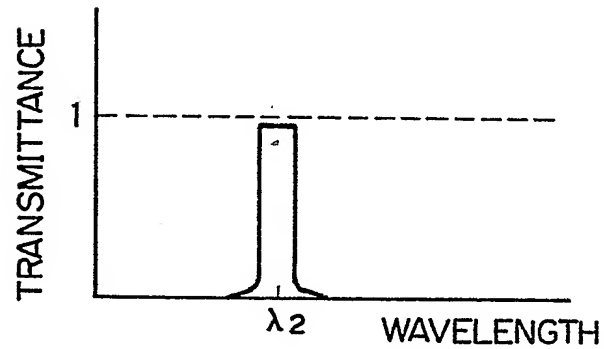
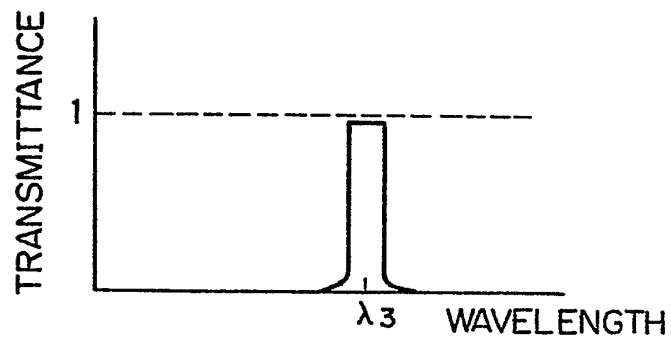
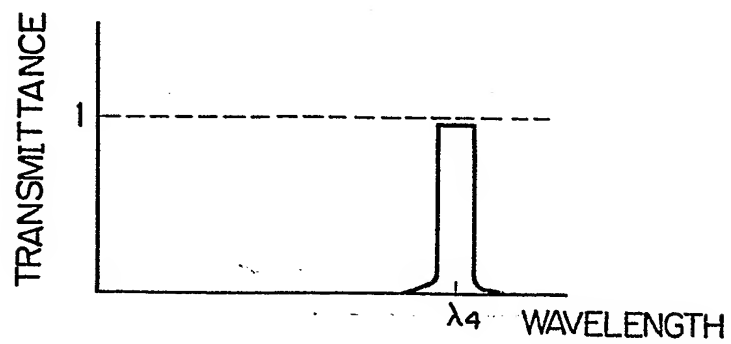
Fig. 6(a)*Fig. 6(b)**Fig. 6(c)**Fig. 6(d)*

Fig. 7(a)

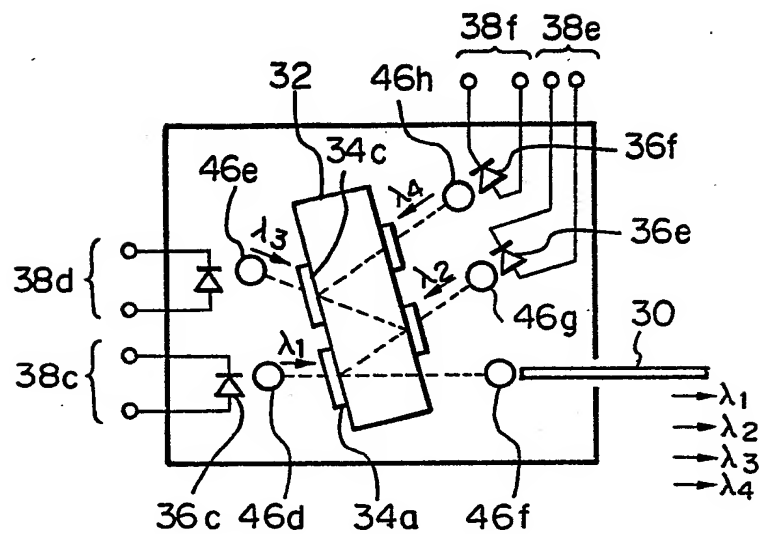


Fig. 7(b)

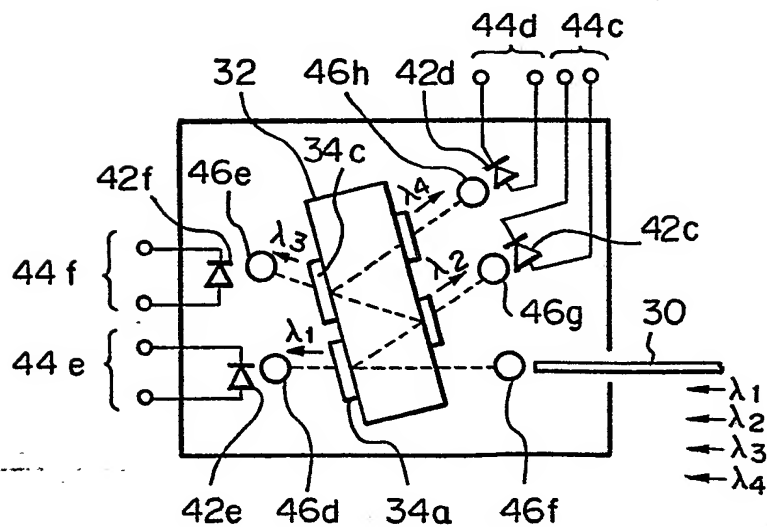
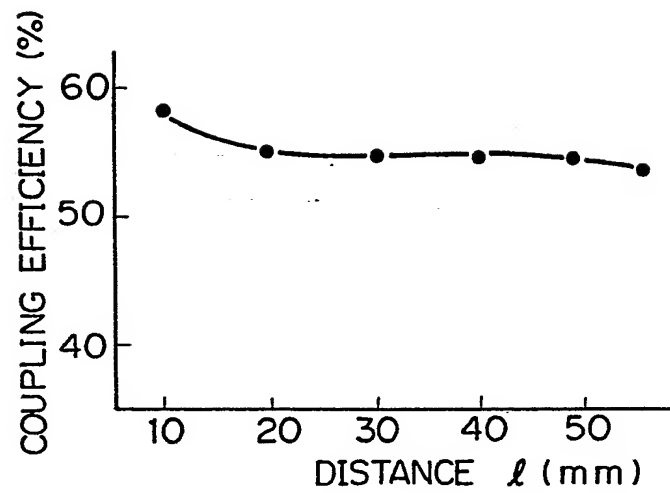


Fig. 8*Fig. 9*